INTEGRATED MANAGEMENT OF SOIL-BORNE PESTS IN FOREST NURSERIES: A SYSTEMS APPROACH

Jennifer Juzwik*[1], Laura Wallach[2], Raymond Allmaras[3], Michael Irvine[4], and Joseph O'Brien[5]

Soil-borne pests affect both quantity of forest nursery seedlings available for lifting and shipping as well as quality (morphological and physiological characteristics) of shipped seedlings destined for a variety of out-planting sites. Broad groups of significant pests in north central states nurseries of the USA include soil-borne fungi (e.g. *Cylindrocladium* spp., *Fusarium* spp., and pythiaceous fungi), insects (e.g. white grubs and cutworms), and weeds (e.g. horseweed, narrowleaf hawksbeard, and chickweed). Since the 1950's much reliance has been placed on pre-plant chemical fumigation of nursery soils to manage these pests in conifer and hardwood seedling fields.

Integrated pest management (IPM) has been the stated goal for USDA Forest Service nurseries since the late 1980's as an outcome of environmental assessments conducted for each one. The IPM plans developed by these federal nurseries were focused on tolerable levels of control for significant pests in each nursery. The aim of these plans is to reduce the reliance on "single-shot" treatments, such as pre-plant soil fumigation with methyl bromide - chloropicrin. Commercial, industrial, and state forest nurseries in the north central region have varied in their approach and commitment to an IPM goal.

Research and development trials conducted in north central USA nurseries during the past 50 years have usually focused on one or two types of treatments such as alternative chemicals, cultural controls, physical methods, avoidance, and classical biological control. These treatments were generally tested for control of one group of pests, e.g. pathogenic fungi or noxious weeds. Application of developed control methods have been adopted into existing nursery cultural regimes when considered economically feasible, effective, easy to apply, and necessary for production of either conifer or hardwood seedling stock. Aside from the cultural practices regime developed for different stock types by individual nurseries, a "systems approach" to integrating numerous developed methods into a usable scheme for testing has been lacking, however.

Operational-level trials were initiated in June 1998 in a Minnesota and a Wisconsin nursery to test a tailor-made, systems approach for managing soil-borne pest problems without the use of methyl bromide - chloropicrin. A primary goal of the large-scale trials is to create a soil environment, down to the maximum rooting depth of the woody crop, that is conducive to healthy root system growth and development, and unfavorable for pest survival and increase. Additional tools for further managing specific groups of pests (e.g. insects or weeds) would be integrated as required.

Progress to Date

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[1] Research Plant Pathologist, USDA Forest Service, North Central Station, St. Paul, MN, USA
[2] Graduate Student, Department of Plant Pathology, University of Minnesota, St. Paul, MN, USA
[3] Research Soil Scientist, USDA - Agricultural Research Service, St. Paul, MN, USA
[4] Vegetation Management Specialist, Ontario Ministry of Natural Resources, Sault Ste. Marie, ON, Canada
[5] Plant Pathologist, USDA Forest Service, Northeastern Area State and Private Forestry, St. Paul, MN, USA

Alternative soil management regimes were devised for fields designated for 1-0 black walnut and 3-0 white pine seedling production in the participating nurseries. Controls consist of each nursery's current soil management practices. The specific schemes developed are found in Tables 1 and 2. The treatments were implemented between early July and mid-October 1998. When possible, evaluation of specific changes made to existing regimes were conducted. For example, pre-trial assessment of levels of selected fungi in the vertical profile of the top 30 cm of soil were made in alternative and control treatment fields. Prior to sub-soiling in the alternative treatment fields, soil resistance to penetration
in the top 45 cm of soil was also determined using a cone penetrometer. Depths of sub-soiling treatments in the alternative treatment fields were based on cone indices curves developed with this data. In addition, *in situ* soil cores were removed prior to sub-soiling in all study fields to determine saturated soil hydraulic conductivity and the soil water retention characteristic. Additional penetrometer readings and *in situ* soil cores were also taken in all study fields in October to determine effect of sub-soiling (modified in Minnesota; new in Wisconsin) on soils in the recently prepared seedbeds.

Future Treatments and Assessments

A weed management plan was developed for black walnut and white pine fields at the Minnesota Nursery by the fourth author. This plan will be implemented through the woody portion of the rotation cycle in the alternative treatment fields. Currently, irrigation management plans based on use of commercially-available TDR (time domain reflectrometery) technology are being developed for both participating nurseries. Implementation of the developed plan will begin in late May 1999 in the alternative treatment fields. Appropriate assessments of both these changes to existing nursery practice will be made during the 1-0 growing season for all trial fields and during 2-0 and 3-0 seasons for the white pine trial fields.

The final, bottom-line assessments of the developed systems tested will include determination of quantity and quality of shippable seedlings from the trial fields in the two nurseries. Additional evaluation of costs, practicality, and feasibility of implementing these regimes will also be made in close collaboration with the cooperating nursery managers.

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Table 1. Soil management treatments in trial fields of the Minnesota nursery prior to establishment of the woody crops.

Approximate time	Activity	Treatment regime: Control	Alternative
early July	traffic lanes and bed locations	• no special attention to where lanes or beds are to be located	• establish where traffic lanes and beds will be located and use traffic lanes in all operations from this date on
mid-July	cover crop incorporation and field preparation	• incorporate using moldboard plow • smooth field with disc 1 to 2 weeks later	• incorporated with heavy discing operation • smooth with light disc 1 to 2 weeks later
late July	sub-soiling	• using existing equipment (3 shanks at 20 inch spacing) • one pass at 45 cm depth with no regard to future traffic lanes or beds	• using two off-set parabolic shanks with winged, “tiger” points • one shallow pass followed by one deep pass in locations where beds will be established
late July	soil amendments	• incorporated peat with rotary tiller	• incorporate peat with spading machine
early August	soil fumigation	• cultivate to prepare field • fumigate with metam sodium	• no fumigation
end of September	bed formation	• establish traffic lanes • form beds with usual equipment	• form beds with spading machine or rotary tiller with wide angle tines (> 110 degrees)
early October	sow seed	• sow white pine and walnut in formed beds	• sow white pine and walnut in formed beds

Table 2. Soil management treatments in trial fields of the Wisconsin nursery prior to establishment of the woody crops.

Approximate time	Activity	Treatment regime: Control	Alternative
early July	traffic lanes and bed locations	• no special attention to where lanes or beds are to be located	• establish where traffic lanes and beds will be located and use traffic lanes in all operations from this date on
mid-July	cover crop incorporation and field preparation	• incorporate using moldboard plow • smooth field with disc 1 to 2 weeks later	• incorporated with heavy discing operation
late July	sub-soiling	• none	• using two off-set parabolic shanks with winged, "tiger" points • one shallow pass followed by one deep pass in locations where beds will be established
early August	field preparation	• light discing to smooth field prior to fumigation	• further incorporate crop residue using spading machine[1]
mid-August	soil fumigation	• using methyl bromide - chloropicrin with plastic seal • slit tarp 5 days later • remove tarp 8 days after fumigation and lightly disc	• using dazomet[2] at 400 lbs/ac • incorporate product with a spading machine • water seal applied and maintained for 7 days
end of September	bed formation	• establish traffic lanes • form beds with usual equipment	• form beds without use of sharp-angle tine tiller
early October	sow seed	• sow white pine in formed beds	• sow white pine in formed beds

[2]1 Discing operation was too light and resulted in shallow incorporation of cover crop residue. A second incorporation with a spading machine was required.

[2]2 Product applied using guidelines developed by Pennington (1995) and Juzwik et al. (1997)